

STEUBENVILLE COMPREHENSIVE AIR MONITORING PROGRAM (SCAMP)

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INTRODUCTION AND OBJECTIVES

The Steubenville Comprehensive Air Monitoring Program is comprised of two complementary and inter-related programs which cannot stand independently. One project is funded through the Ohio Department of Development (ODOD) Coal Development Office (CDO) under Grant Agreement No. CDO/D-98-2. The other project is described in Unsolicited Proposal No. P9908026 “Characterization of the PM_{2.5}, PM₁₀, and Gaseous Priority Pollutants in Steubenville, OH and the Surrounding Region” submitted to the U.S. DOE/ FETC January 29, 1999.

The goals of the program are:

- to measure the fine and coarse outdoor particulate matter (PM_{2.5} and PM₁₀) and co-pollutant concentrations at a central urban site, four remote sites, and at the homes of participating individuals;

- to measure the indoor PM_{2.5} and co-pollutant concentrations in the living environment of participating individuals;

- to measure the PM_{2.5} and co-pollutant concentrations of the Apersonal@ environment of participating individuals;

- to evaluate the relationships between concentrations and personal exposure to indoor, outdoor, and personal PM_{2.5}, and indoor, outdoor, and personal co-pollutants;

- to evaluate the relationships among indoor, outdoor, and personal PM_{2.5} concentrations and indoor, outdoor, and personal co-pollutants;

- to compare PM_{2.5} and PM₁₀ collected at urban and remote-sites; to characterize the indoor, outdoor, and personal PM_{2.5} physical and chemical nature;

- to evaluate the toxicological effects of fine particles;

- to collect hourly weather data and daily pollen and mold spore counts;

to provide a comprehensive data base for use in epidemiological studies, long-range transport studies, and State Implementation Program compliance.

SCAMP STATEMENT OF WORK

Tasks are delineated by sampling location: “Outdoor (O)” and “Indoor (I)”. Outdoor includes sampling and analyses of samples obtained at the central urban site, the four remote sites and outside the homes of participating individuals. In addition, the tasks include statistical analyses of these data and the data base resulting from this work. Indoor includes sampling and analyses of samples obtained in the homes of participating individuals and the “personal” air of those individuals. The corresponding statistical analyses tasks and resultant data base from the samples collected indoors are included with the indoor sampling and analyses tasks. A cross comparison between the indoor and outdoor data is shared by both projects to meet the overall SCAMP objectives.

Outside Tasks (O)

Task O1. Outside Project Management

The proposed work will be conducted under the direction of a project management team headed by CONSOL Inc., Research & Development Department. CONSOL will be the prime contractor to the Department of Energy (DOE) and will form a team with DOE, Harvard University School of Public Health, The Ohio University, Wheeling Jesuit University, and St. Vincent's College. The project team will determine the direction of the research, finalize the work plan, and carry out the work. The participants will form a Project Advisory Committee (PAC) with representation from the project team, DOE, Ohio EPA, the Ohio Coal Development Office, the Electric Power Research Institute, individual electric utilities, and several industrial and trade organizations. The PAC will provide input to the Work Plan. The PAC will review the project status and will review status reports.

Task O2. Outside Sampling, Data Collection, and Analyses

This task is subdivided into three subtasks.

Subtask O2.1 - Urban Central Site Outdoor Air Sampling, Data Collection, and Analysis. The purpose of this subtask is to establish and operate an ambient air monitoring super site at an urban Steubenville, OH, location. PM_{2.5}, PM₁₀, priority gaseous pollutants (CO, SO₂, NO₂, total hydrocarbons, and O₃), and ammonia concentration data will be collected. Meteorological data (wind speed and direction, air temperature, relative humidity, barometric pressure, precipitation and solar radiation) and pollen and mold spore counts also will be collected at this site. Samples and data will be collected daily for two years using Federal Reference Methods (FRM) for the particulate matter and continuous monitors for the gases. PM_{2.5} samples also will be collected daily on a quartz filter (instead of a Teflon filter as required by the FRM) to provide particle samples suitable for carbon (organic and elemental) determinations.

Approximately one-fourth of the collected PM_{2.5} samples will be characterized to determine average composition. Samples collected every fourth day will be characterized. Additional analyses will be performed on samples collected during episodes of high PM_{2.5} concentration. Routine analysis of the PM samples will include water-soluble sulfate, nitrate, and ammonium concentrations using ion chromatography; water-soluble elemental analysis using inductively coupled plasma-atomic emission spectrometry (ICP-AES) and inductively coupled plasma-mass spectrometry (ICP-MS); and total carbon content using a combustion-CO₂ collection gravimetric method. Non-routine analyses to be performed on selected samples will include: organic and elemental carbon content using thermal optical reflectance spectroscopy or Fourier Transform Infrared Spectrometry; single particle characterization using Raman chemical imaging; total elemental analysis using ICP-AES and ICP-MS; and alveolar tissue response using bioassay.

The ambient outdoor air in Steubenville, OH, an inland U.S. city, will be characterized. The variability in particulate and gaseous pollutant concentrations and average particulate composition will be examined as a function of day-of-the-week, season-of-the-year, and weather conditions. The collected data will be used to assess whether PM_{2.5} or PM₁₀ concentrations correlate with the gaseous pollutant concentrations or the pollen and mold spore count.

Subtask O2.2 - Remote Outdoor Air Sampling and Analyses. The purpose of this subtask is to install and operate Federal Reference Method (FRM) PM_{2.5} monitors at four remote sites centered around the super site location near Steubenville, OH. The four locations will be located at approximately the four compass points in relation to Steubenville. Samples will be collected daily for two years using the FRM for PM_{2.5}. Additional PM_{2.5} samples will be collected daily on quartz filters to provide particle samples suitable for carbon (organic and elemental) determinations. Approximately one-fourth of the collected PM_{2.5} samples will be characterized to determine average composition using the same methods described in Subtask O2.1 above.

The ambient outdoor PM_{2.5} concentration in the region surrounding Steubenville, OH, will be characterized. The temporal and seasonal variability in PM_{2.5} concentration also will be examined. The data collected in Subtask O2.2 will be used in combination with the data collected in Subtask O2.1 to determine if the regional and urban PM_{2.5} concentrations and compositions correlate.

Subtask O2.3 - Local Home Outdoor Sampling and Analyses. The purpose of this subtask is to measure the daily pollutant concentration immediately outside of the homes of people considered to be particularly at risk for adverse health effects from airborne pollutants. The field work for this subtask will be performed by the Harvard University School of Public Health (HSPH). The outdoor concentrations of particulate matter (PM_{2.5} and PM₁₀) and gaseous pollutants (CO, SO₂, NO₂, and O₃) will be measured outside of 30 homes chosen from volunteers in the Steubenville area. Data will be collected at each location for one week in the winter 1999-2000, one week in summer 2000, and one week in the winter 2000-2001, using an integrated multi-pollutant monitor recently developed at HSPH. The sensitivity, accuracy, and precision of this monitor has been demonstrated in previous studies performed by HSPH. HSPH will provide the monitors for this study. Approximately one-fourth

of the PM samples collected will be characterized to determine average composition using the same methods described in Subtask O2.1 above.

The air quality immediately outside of the homes of the at-risk groups will be determined. The temporal and seasonal variability in particulate matter and gaseous pollutant concentrations will be examined as a function of location. The data will be used to assess whether PM_{2.5} or PM₁₀ is correlated with gaseous pollutant concentrations.

In addition to characterizing the local outdoor air quality, the data collected in this task, in combination with the data collected in Subtask O2.1, will be used to determine the association between outdoor air quality at several local home sites and air quality at a central urban site for each of the measured pollutants.

Task O3. Statistical Analysis of Outside Data

The objective of this task is to develop the correlations among urban central site, local home site, and remote site PM_{2.5} concentrations and the correlations among the outdoor ambient concentrations of PM_{2.5}, PM₁₀, and gaseous pollutants. Ultimately, these correlations will determine the appropriateness of the exposure assessment methods typically used in epidemiological studies. The data collected in Task O2 will be analyzed using descriptive statistics and graphs. Analyses will focus on how pollutant concentrations vary with location, season, and weather conditions. The data also will be analyzed to determine whether a correlation can be found between central site ambient outdoor concentrations and the concentrations measured outside of individual homes. The data will be examined to determine if the particulate matter concentrations correlate with (or are confounded by) other pollutants, meteorological conditions, or pollen and mold spore count.

Task O4. Reporting of Outside Data

The purpose of this task is to ensure effective communication among project participants. CONSOL R&D, as prime contractor, will assume the responsibility for delivery of all reporting. CONSOL will submit all reports in accordance with the DOE Uniform Reporting System for Federal Assistance.

Monthly status reports will be used to communicate monitoring results on an interim basis. A final technical report will provide a compilation of the monitoring results and a detailed description of the statistical analyses and results. One element of reporting includes meetings with project participants and stakeholders at the urban and remote sampling sites: Washington, DC, and Research Triangle Park, NC. Results will be presented at scientific and technical meetings.

Inside and Personal Tasks (I)

Task I1. Inside Project Planning and Management

CONSOL R&D shall prepare and submit a Project Management Plan to the OCDO Project Officer within thirty (30) days following the contract initiation. This plan shall be self-contained and shall present in detail all activities that will be performed for the successful completion of the work outlined in this Statement of Work.

Task I2. Inside Sampling, Data Collection, and Analyses

CONSOL R&D will subcontract with the Harvard University School of Public Health (HSPH) to perform the test subject selection and the sample collection. HSPH will subcontract with Ohio colleges/universities (or as appropriate, Ohio hospitals) for some of the sample collection and data analysis. Prior to the full test, the personal sampler design will be modified and a pilot test will be performed. CONSOL R&D will subcontract with HSPH to perform the sampler modifications and pilot test sample collection.

Subtask I2.1 - Methods Development and Pilot Study. The design of the Harvard multi pollutant personal sampler used in previous studies will be modified. The current design collects samples to measure PM_{2.5}, PM₁₀, sulfate, O₃, NO₂, SO₂, and CO in personal breathing space. After modification, the samplers also will measure nitrate, water-soluble elements, and organic and elemental carbon. A pilot study will be conducted in Steubenville, OH, to test the new design. To determine the accuracy of the design, a modified sampler will be co-located with a fine particulate Federal Reference Method instrument and gaseous criteria pollutant measurements. In addition, three adults will be selected to wear the personal sampler for the pilot study. Ten measurements will be made for each adult.

The filter samples collected in the pilot study will be used to compare XRF and ICP-MS methods for elemental analysis of particulate matter samples. XRF is typically used for elemental analysis of ambient air particulate matter samples; however, ICP-MS is more sensitive than XRF for the detection of most elements. Sample digestion is required for ICP-MS analysis, but not for XRF analysis. Selected samples will be analyzed by XRF first, followed by analysis of the same samples using ICP-MS, and the results will be compared. In addition, samples containing known concentrations of common particulate matter elements will be prepared and analyzed by both methods for comparison.

Particulate and gaseous concentrations measured using the Harvard multi-pollutant samplers will be compared to those measured using reference samplers for each pollutant of interest. The Harvard multi-pollutant samplers will be used to measure PM_{2.5}, elemental and organic carbon (EC/OC), nitrate, sulfate, ozone, and sulfur and nitrogen dioxide concentrations. PM_{2.5} concentrations will be obtained on two filters, both of which will be weighed for total mass.

In the method inter-comparison tests, two multi-pollutant samplers will be colocated with one reference sampler for each pollutant of interest. All samplers will be colocated at a SAM site. A total of ten to 20 sample sets will be collected to assess the performance of the multi-pollutant samplers. Sampler performance will be assessed individually for each pollutant by comparison of the concentrations measured using the multi-pollutant sampler with those measured using the reference sampler.

Laboratory inter-comparisons will be conducted to ensure that the laboratory gravimetric and ion chromatographic analysis was performed correctly. Ten to 20 sets of three samplers (at a minimum) will be collocated at the SAM site. PM_{2.5} and inorganic ion concentrations will be determined independently by Harvard and CONSOL laboratories, with a third laboratory used if the laboratory results do not agree.

Subtask I2.2 Summer 2000 and Winter 2001 (Panel Study of Older Adults). This subtask is intended to characterize the particulate and gaseous exposures of independently living, older adults. Planning for Subtask I2.2 will begin in November 1999. Monitoring for Subtask I2.2 will be performed after satisfactory completion of the Task I2.1 inter-comparison studies. The monitoring component is expected to begin in June 2000.

In Subtask I2.2, the indoor concentrations and personal particulate and gaseous exposures will be characterized for a panel of 25 older adults living in Steubenville, OH, community housing complexes. Each of these individuals will live "independently" and will control their own home ventilation conditions.

Study participants will be recruited from a population of older adults living in community-based housing. Participants will be selected based on their non-smoking status, their ability to live independently, and their ability and willingness to participate in this project and in a concurrent project on heart rate variability.

Subtask I2.2 will be performed in two seasons: Summer 2000 and Winter 2001. In each season, repeated 24-h indoor particulate and gaseous air pollutant monitoring will be performed inside the homes of 25 individuals. For each individual, indoor monitoring will be performed two days each week for a total of ten weeks (Figure 1). Indoor samples will be collected for five or ten participants each day. Twenty indoor samples will be collected for each participant each season, for a total of 500 indoor samples.

Corresponding 24-h personal particulate and gaseous exposures will be measured for ten of the 25 individuals. Personal exposures will be measured for two or four participants each day. Each season, twenty personal samples will be collected for each of the ten participants, for a total of 200 personal particulate and gaseous samples.

All indoor samples will be collected using the multi-pollutant sampler, which will be used to measure 24-h PM_{2.5}, EC/OC, nitrate, sulfate, water-soluble and total element, O₃, SO₂, and NO₂ concentrations. Indoor samplers will be placed inside the main activity room of each participant's home, with the inlets placed at four feet high to correspond to the breathing level of the individual. Each of the PM_{2.5} PEMs will sample at a flow rate of 4 LPM; the speciation samplers for EC/OC and nitrate/sulfate will each sample air at 0.8 LPM.

The same multi-pollutant sampler will be used to measure the 24-h personal particulate (PM_{2.5}, EC/OC, nitrate, sulfate, water-soluble and total elements) and gaseous (O₃, SO₂, NO₂) exposures for

ten of the participants. Each of these ten individuals will be asked to wear a sampler for two days each week. [Personal monitoring will be performed on the same days as indoor monitoring.] The multi-pollutant sampler inlet will be placed at breathing height. The pump, battery pack, and tubing will be stored in a backpack. Each of the PM_{2.5} PEMs will sample at a flow rate of 1.8 LPM; the speciation samplers for EC/OC and nitrate/sulfate will each sample at 0.8 LPM.

In addition to the air pollutant monitoring, time/activity and housing characteristics data will be obtained for each of the study participants for each two-day monitoring period. Participants will be given a time/activity diary at the beginning of each monitoring day, on which the participant will be asked to record information about each new activity, including a brief description of the activity as well as its location, start time, and stop time. At the end of each monitoring day, field technicians will administer a housing questionnaire to each participant, who will be asked questions about home ventilation characteristics and household activities that occurred within the home.

Harvard will recruit the study participants and will coordinate and supervise the indoor and personal sampling. Harvard will provide all of the monitors and filters for the study. Harvard will pre-weigh all Teflon filters prior to sampling. The Franciscan University of Steubenville (FUS) will perform indoor and personal sampling. After sampling, FUS will transfer the PM_{2.5} samples to Harvard, where they will be weighed. Upon completion of the gravimetric analysis, weighed filters will be transported to CONSOL R&D in Library, PA for elemental analyses. Cartridges containing nitrate, sulfate, EC/OC, O₃, SO₂, and NO₂ samples will also be sent to Harvard, who will transfer the sample filters to sample vials. The sample vials will be sent to CONSOL R&D for ion chromatographic and EC/OC analyses. Harvard will be responsible for all time/activity and housing characteristics data and will provide the data to CONSOL R&D to be entered into the program database. CONSOL will provide the completed program database in database (or spreadsheet) format to Harvard.

Subtask I2.3. Winter 2001 and Summer 2001 (Panel Study of Children). Indoor concentrations and personal particulate and gaseous exposures will be characterized for fifteen children living in Steubenville, OH. For each child, simultaneous indoor and personal particulate (PM_{2.5}, EC/OC, nitrate, sulfate, water-soluble and total elements) and gaseous (O₃, SO₂, NO₂) samples will be collected for 24-h periods on seven days in each season. Three children will be measured concurrently each week, with all monitoring to occur over a six week period. 24-h air exchange rate, time/activity, and housing characteristics data will also be collected for each child on each monitoring day. For each pollutant, a total of 210 personal, 210 indoor, and 210 outdoor samples will be collected.

All personal and indoor particulate and gaseous samples will be collected using the Harvard multi-pollutant sampler, which will simultaneously measure PM_{2.5}, EC/OC, nitrate, sulfate, water-soluble, and total elements, O₃, SO₂, and NO₂ concentrations. On each of the monitoring days, each child subject will wear an integrated multi-pollutant monitor for a 24-h period. The monitor will be attached to the shoulder strap of a backpack, with the inlet of the monitor placed at breathing height. The pump, battery pack, and tubing will be stored in the backpack. Indoor multi-pollutant monitors will be placed in the main living area of the child's home. The inlet of these indoor monitors will be placed at 4 feet high to correspond to the child's breathing height. Harvard with assistance from FUS will

recruit the study participants from local schools and youth centers and will coordinate and supervise the indoor and personal sampling. Harvard will provide all of the monitors and filters for the study. Harvard will pre-weigh all Teflon filters prior to sampling. The Franciscan University of Steubenville (FUS) will perform indoor and personal sampling. After sampling, FUS will transfer the PM_{2.5} samples to Harvard, where they will be weighed. Upon completion of the gravimetric analysis, weighed filters will be sent to CONSOL R&D in Library, PA, for elemental analyses. Cartridges containing nitrate, sulfate, EC/OC, O₃, SO₂, and NO₂ samples will also be sent to Harvard, which will transfer the sample filters to sample vials. The sample vials will be sent to CONSOL R&D for ion chromatographic and EC/OC analyses. Harvard will be responsible for all time/activity and housing data and will provide the data to CONSOL R&D to be entered into the program database. CONSOL will provide the completed program database to Harvard.

Task I3. Statistical Analysis of Inside Data

HSPH will analyze the data collected in Task I2. Personal exposures will be compared for each of the measured pollutants across seasons using paired t-tests, independent sample t-tests, or their non-parametric equivalents. Activity patterns will be analyzed across seasons and sensitive population subgroups using multivariate methods for discrete data. More complex analytical methods, such as generalized estimating equations and mixed models, will be used to account for correlations that arise as a result of repeated observations over time on the same individuals.

The relationship between personal exposures and corresponding outdoor concentrations will be evaluated for each of the measured pollutants using Spearman correlation coefficients, linear and multivariate regression techniques, and generalized linear modeling techniques. Data will be analyzed to examine whether the observed associations between particulate matter concentrations and adverse health effects can result from confounding by gaseous pollutants. The relationship among ambient particulate and gaseous concentrations and among personal particulate and gaseous concentrations will be assessed using similar statistical techniques, with results from the analysis of outdoor concentrations and of personal exposures compared.

Task I4. Reporting of Inside Data

CONSOL R&D will submit all status, technical management and environmental reports in accordance with the reporting requirements checklist